* Antenna Measurements :

The Antenna measurements are done in three ways. They are :

1. Impedance Measurement.
2. Radiation pattern measurement.
3. Gain measurement.
   ↳ 3a. Direct Comparision method
   3b. Absolute method
   ↳ (i) 2 Antenna method
   (ii) 3 Antenna method

1. Impedance Measurement :

The impedance measurement is done depending on the frequency. For frequency less than 3MHz wheatstone bridge method is employed. Whereas for frequencies above 1000MHz slotted line measurement is used.

(a) Wheatstone Bridge method : This method is used to measure the unknown impedance by comparision with known impedance. It consists of four impedances which are given as z_1, z_2, z_3 and z_4 connected in four arms of the bridge as shown in fig.

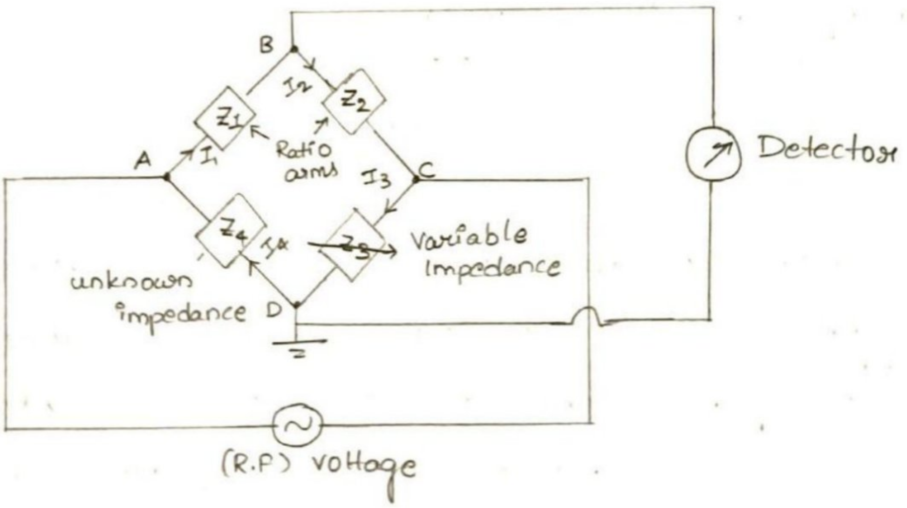


Fig : Wheatstone Bridge Method

The arms Z_1 and Z_2 are called as "ratio arms" and Z_3 is called as "variable arm" impedance which is varied to get null in the detector and Z_4 the unknown impedance under measurement. When the bridge is balanced by varying impedance Z_3 no potential difference exists between point R and D and meter in the detector circuit will give a null. Under this condition we can write it as

$$\frac{Z_1}{Z_2} = \frac{Z_4}{Z_3} \quad \text{------} \; (1) \quad \text{(Balanced condition)}$$

Since the impedance contains both real as well as imaginary part it is represented in magnitude and phase as below:

$$\frac{Z_1 \angle\theta_1}{Z_2 \angle\theta_2} = \frac{Z_4 \angle\theta_4}{Z_3 \angle\theta_3}$$

$$Z_1 Z_3 \angle(\theta_1+\theta_3) = Z_2 Z_4 \angle(\theta_2+\theta_4)$$

Thus there are two balance conditions which should be satisfied simultaneously as follows.

$$Z_1 Z_3 = Z_2 Z_4 \;;\; \angle(\theta_1+\theta_3) = \angle(\theta_2+\theta_4)$$

From (1) we can find the unknown impedance of the antenna by using the formula:

$$\boxed{Z_4 = Z_3\left[\frac{Z_1}{Z_2}\right]}.$$

(6) Slotted line Method (or) Standing wave Ratio method:

Slotted line method of impedance measurement is based on the well-known characteristics of standing waves. We can calculate the impedance from the knowledge of VSWR, and reflection coefficient and characteristic impedance. By using the parameters we can measure the input impedance of antenna.

$$\boxed{Z_L = Z_0 \left[\frac{1+K}{1-K}\right]} \quad \text{----} (1)$$

where Z_L = Antenna Impedance.

Z_0 = Characteristic Impedance = $120\pi\,\Omega$

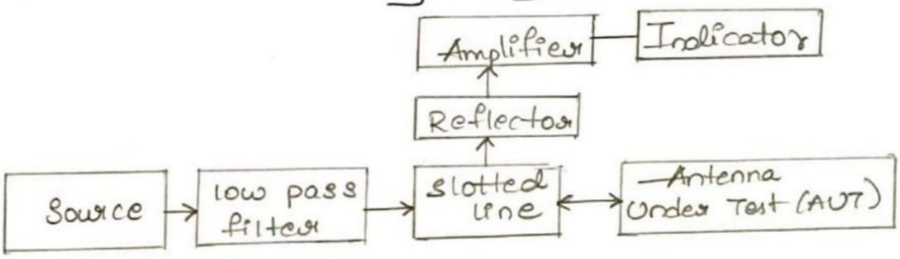
K = reflection coefficient.

$$K = \frac{S-1}{S+1}$$

S = standing wave ratio

$$\boxed{S = \frac{V_{max}}{V_{min}}}$$

To find these maximum and minimum values of the standing wave ratio we have an arrangement or setup to determine them. It is shown in following diagram below:



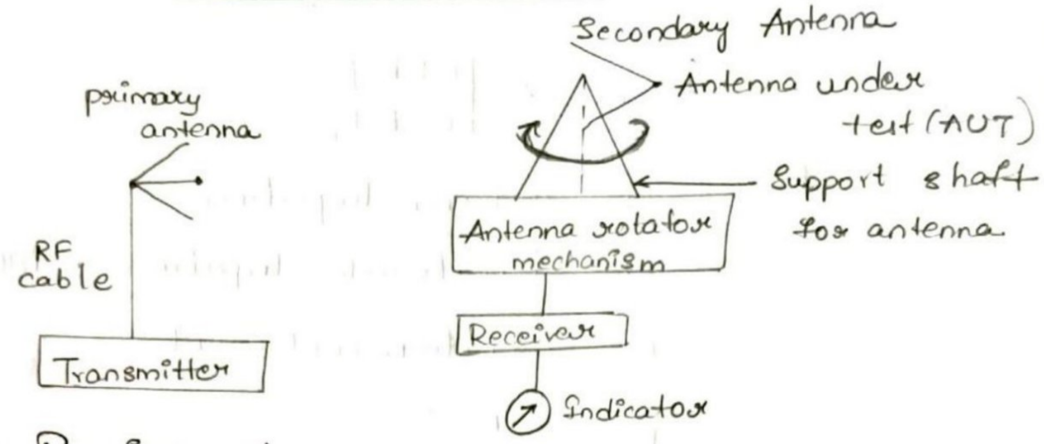
Also after finding V_{max}, V_{min} we can substitute the 'S' value in 'K', by using the reflection coefficient we can easily find the unknown Impedance.

2. Radiation Pattern Measurement :

The radiation pattern depends on a fixed distance (r) and a fixed frequency (f), elevation angle (θ) which varies from 0° to 180°. To achieve the proper radiation pattern at the recorder there are some conditions those should be satisfied. They are : (i) Distance Requirement.

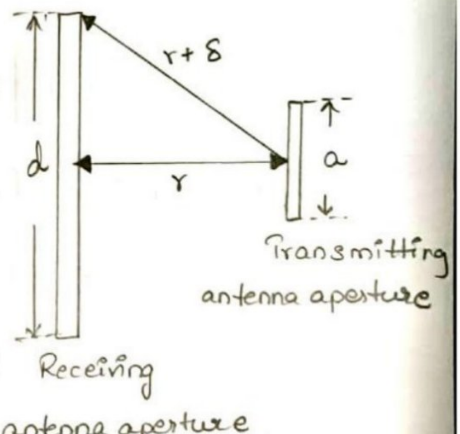
(ii) Uniform illumination Aperture.

Scanned with CamScanner



(i) Distance Requirement:

In order to attain accurate far field radiation measurement the distance between the primary and secondary antenna should be large. If the separation is small then we get near field measurement. To get far field measurements the secondary antenna should be properly illuminated by a plane wave front from the primary antenna. So the minimum distance that should be maintained between the primary and secondary antenna should be



From $OAB \Rightarrow (r+\delta)^2 = r^2 + \left(\frac{d}{2}\right)^2$

$$\cancel{r^2} + \delta^2 + 2r\delta = \cancel{r^2} + \frac{d^2}{4}$$

$$\delta^2 + 2r\delta = \frac{d^2}{4}$$

where δ is negligible

$$\boxed{r = \frac{d^2}{2\delta}}$$

→ The minimum distance requirement are $\boxed{r \geq \frac{2d^2}{\lambda}}$

where r = distance between transmitter & receiver

d = maximum dimension of aperture

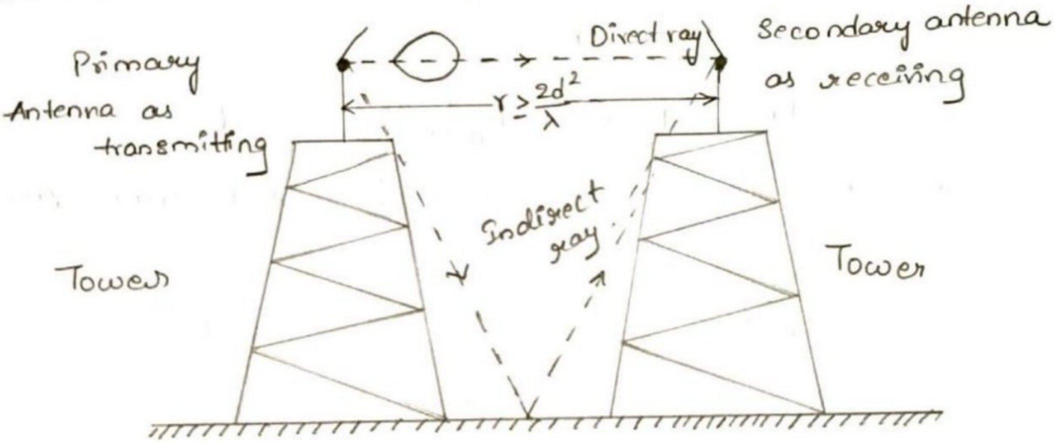
λ = operating wavelength.

(ii) Uniform illumination Aperture :

In uniform illumination Aperture from transmitting antenna to receiving antenna there are 2 ways. They are:

1. Direct path
2. Indirect path.

The other condition to be satisfied is primary antenna should provide a plane wave front of uniform amplitude and phase over the distance equal to 'r'. The interference between the direct and indirect rays should be avoided as far as possible. Besides the reflections from the surrounding building, trees should also avoid. So, the test antenna should be mounted on towers or above the buildings.



3. Gain Measurement :

The gain of any antenna can be found by using any of two methods specified below. They are

a. Direct Comparision Method.

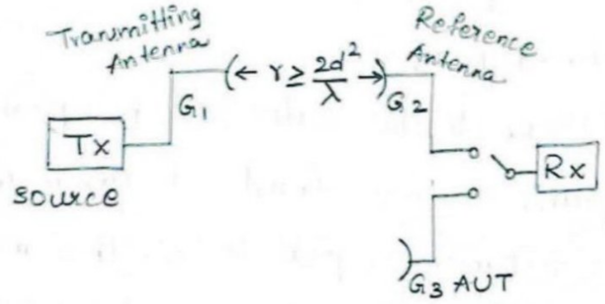
b. Absolute Method.

(i) Two Antenna Method.

(ii) Three Antenna Method.

(a) Direct Comparision Method:

In direct comparision method a transmitting antenna is arranged at the source and a reference antenna and an antenna under test (AUT) are arranged at the receiver with a switch.



We know the gain of reference antenna so by using the FRIIS transmission formula

$$\boxed{P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi R}\right)^2}$$

If the switch is connected to reference antenna then the received power is given by

$$\boxed{P_{R2} = P_{T_1} G_1 G_2 \left(\frac{\lambda}{4\pi R}\right)^2} \quad \text{----(1)}$$

If the switch is connected to AUT then received power is given by

$$\boxed{P_{R3} = P_{T_1} G_1 G_3 \left(\frac{\lambda}{4\pi R}\right)^2} \quad \text{----(2)}$$

→ By taking the ratio of (1) & (2)

$$\frac{P_{R2}}{P_{R3}} = \frac{\cancel{P_{T_1}} \cancel{G_1} G_2 \cancel{\left(\frac{\lambda}{4\pi R}\right)^2}}{\cancel{P_{T_1}} \cancel{G_1} G_3 \cancel{\left(\frac{\lambda}{4\pi R}\right)^2}}$$

$$\therefore \frac{P_{R2}}{P_{R3}} = \frac{G_2}{G_3}$$

As we have to find the gain of the Antenna under test (AUT) i.e., $G_3 = \left(\frac{P_{R3}}{P_{R2}}\right) G_2$

$$\boxed{G_{AUT} = \left[\frac{P_{R3}}{P_{R2}}\right] G_{ref}}$$

(b) Absolute Method:

(i) Two Antenna Method -

In 2 Antenna method we will consider two identical Antenna's which are having similar gain, similar height and similar significances. In this method by using the FRIIS transmission formula:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi R}\right)^2$$

$$G_T G_R = \frac{P_R}{P_T}\left(\frac{4\pi R}{\lambda}\right)^2$$

By applying log on both sides

$$10\log(G_T G_R) = 10\log\left[\frac{P_R}{P_T}\left(\frac{4\pi R}{\lambda}\right)^2\right]$$

$$10\log G_T + 10\log G_R = 10\log\left(\frac{P_R}{P_T}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right)$$

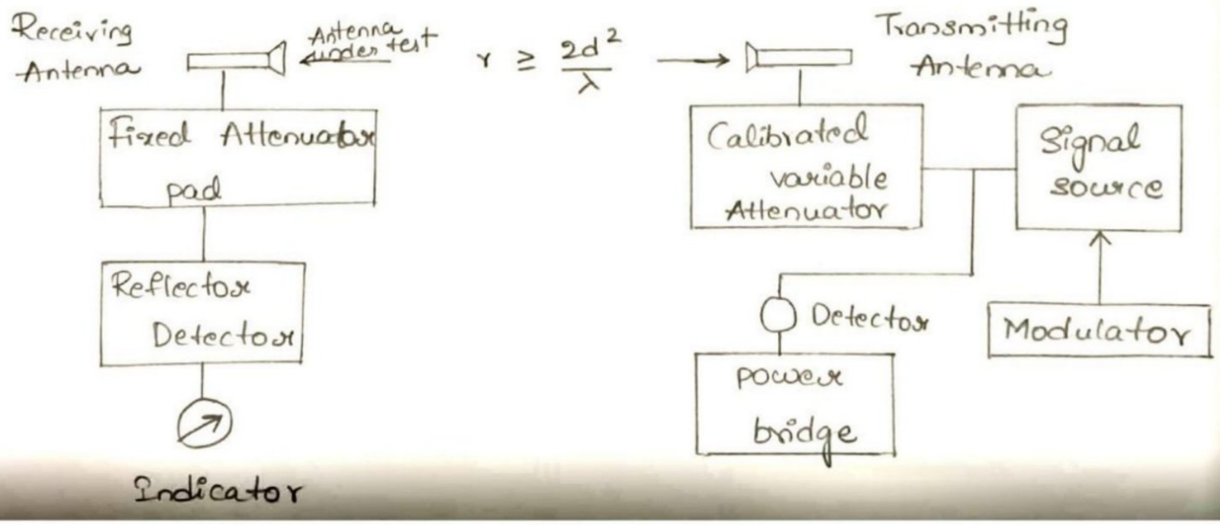
$$\boxed{(G_T)_{dB} + (G_R)_{dB} = 10\log\left(\frac{P_R}{P_T}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right)}$$

As we know that two antenna's are identical

$$(G_T)_{dB} = (G_R)_{dB}$$

$$\therefore \quad 2(G_T)_{dB} = \left[10\log\left(\frac{P_R}{P_T}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right)\right]$$

$$(G_T)_{dB} = \frac{1}{2}\left[10\log\left(\frac{P_R}{P_T}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right)\right]$$



(ii) Three Antenna Method:

If the two antenna method two antenna's are not identical then we will use the 3 Antenna Method.

The gain of three antenna's is given by G_1, G_2, G_3.

→ From antenna-1 & antenna 2 we have the formula

$$(G_1)_{dB} + (G_2)_{dB} = 10\log\left(\frac{P_{R2}}{P_{T1}}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right) \rightarrow (1)$$

For Antenna 1 & Antenna 3:

$$(G_1)_{dB} + (G_3)_{dB} = 10\log\left(\frac{P_{R3}}{P_{T1}}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right) \rightarrow (2)$$

For Antenna 2 & Antenna 3:

$$(G_2)_{dB} + (G_3)_{dB} = 10\log\left(\frac{P_{R3}}{P_{T2}}\right) + 20\log\left(\frac{4\pi R}{\lambda}\right) \rightarrow (3)$$

By solving the equation (1), (2) & (3) we can find the gain.